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ADVANCED DESIGN LINEAR NOISE-ATTENUATING EARPHONE-EARCUP SYSTEM--ETC(U)
AUG 81 R B JACKSON, M A BRYSON DAAK80-80-C-0556

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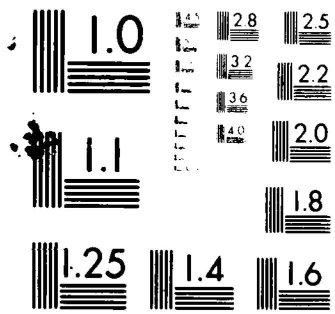
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RESEARCH AND DEVELOPMENT TECHNICAL REPORT
CECOM

ADVANCED DESIGN LINEAR NOISE-ATTENUATING
EARPHONE-EARCUP SYSTEM

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August 1981

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THIS DOCUMENT COVERS THE DEVELOPMENT OF A HEADSET DESIGNED TO IMPROVE INTELLIGIBILITY AND REDUCE EAR FATIGUE OF COMBAT VEHICLE CREWMEN IN ARMORED VEHICLES. IT IS ELECTRICALLY EQUIVALENT TO THE MK-1697/G KIT, BUT IS SELF SUPPORTING AND IS NOT DESIGNED TO FIT ANY PARTICULAR HELMET.

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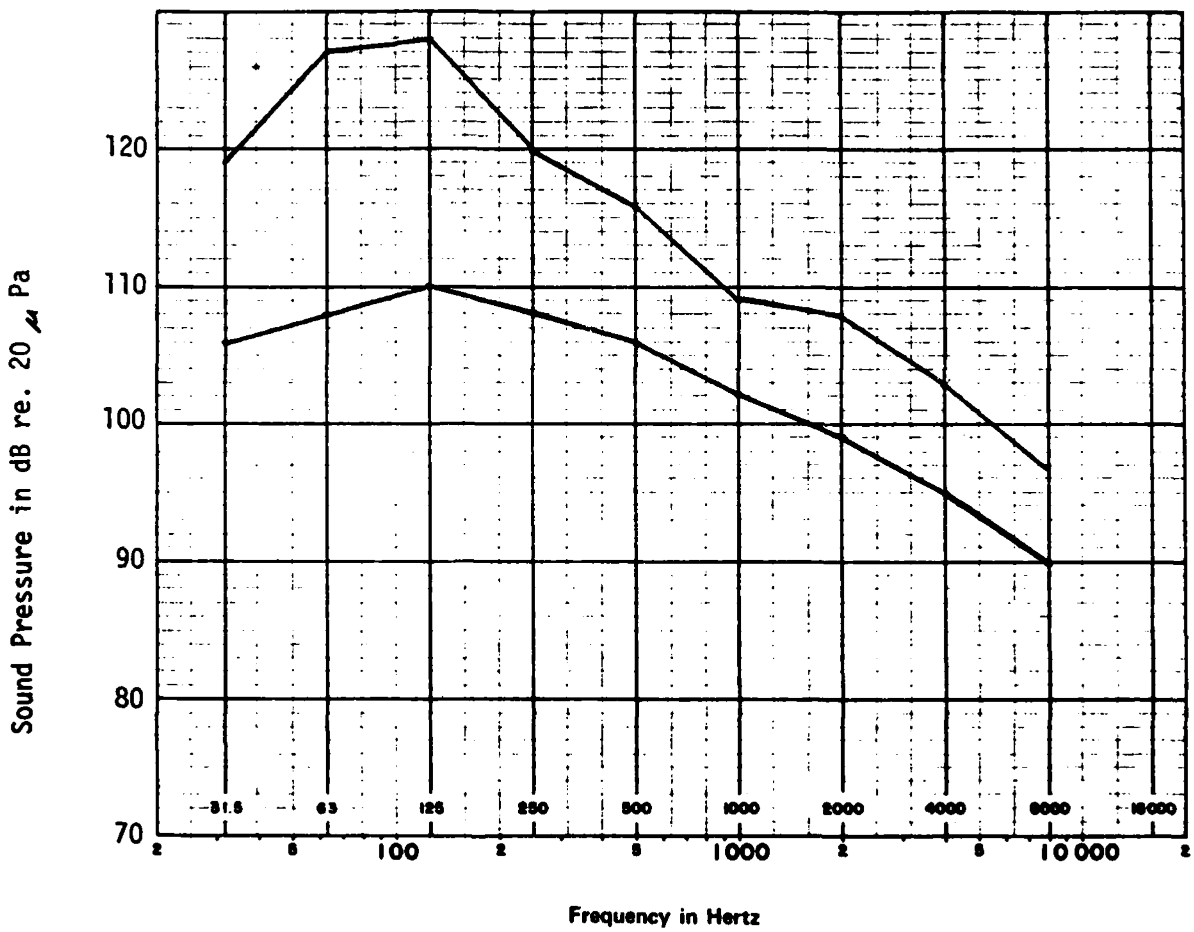
OBJECTIVE

The objective of the technical effort described herein was to develop a noise attenuating headset kit independent of any helmet design now in use by the Army. By not restricting the configuration of the kit to one compatible with an existing helmet, the developers believed they could concentrate on achieving better noise attenuation. An earphone element had to be developed to provide essentially flat response on a human head wearing the kit. In addition, a study of the effects of contaminants on the urethane earcushion covers was undertaken, and a boot was designed to waterproof the junction of U-173, U-172, JJ-055, and PJ-292 connectors.

THE NOISE PROBLEM

High sound pressure levels of noise are generated within the mechanized vehicles used by the Army. The noisiest vehicles are those utilizing tracks such as armored carriers and tanks. Figure 1 shows an envelope of the noise generated by an Infantry Fighting Vehicle (IFV). To comply with the requirements of MIL STD 1474A, CAT D (reproduced in part in Table I) protective earplugs must be worn under the presently available headsets and helmets by persons riding in these vehicles.

Wearing earplugs under the headsets and helmets does reduce noise fatigue and does conserve the hearing of the wearer, but it causes problems in that the plugs also block out the signal or preferred sound from the earphones. The response of a typical earphone-earcup combination is shown in Figure 2.



ENVELOPE OF NOISE SOUND PRESSURE LEVELS
FOR PROTOTYPE COMBAT TRACKED VEHICLE

Figure 1

Form 1396

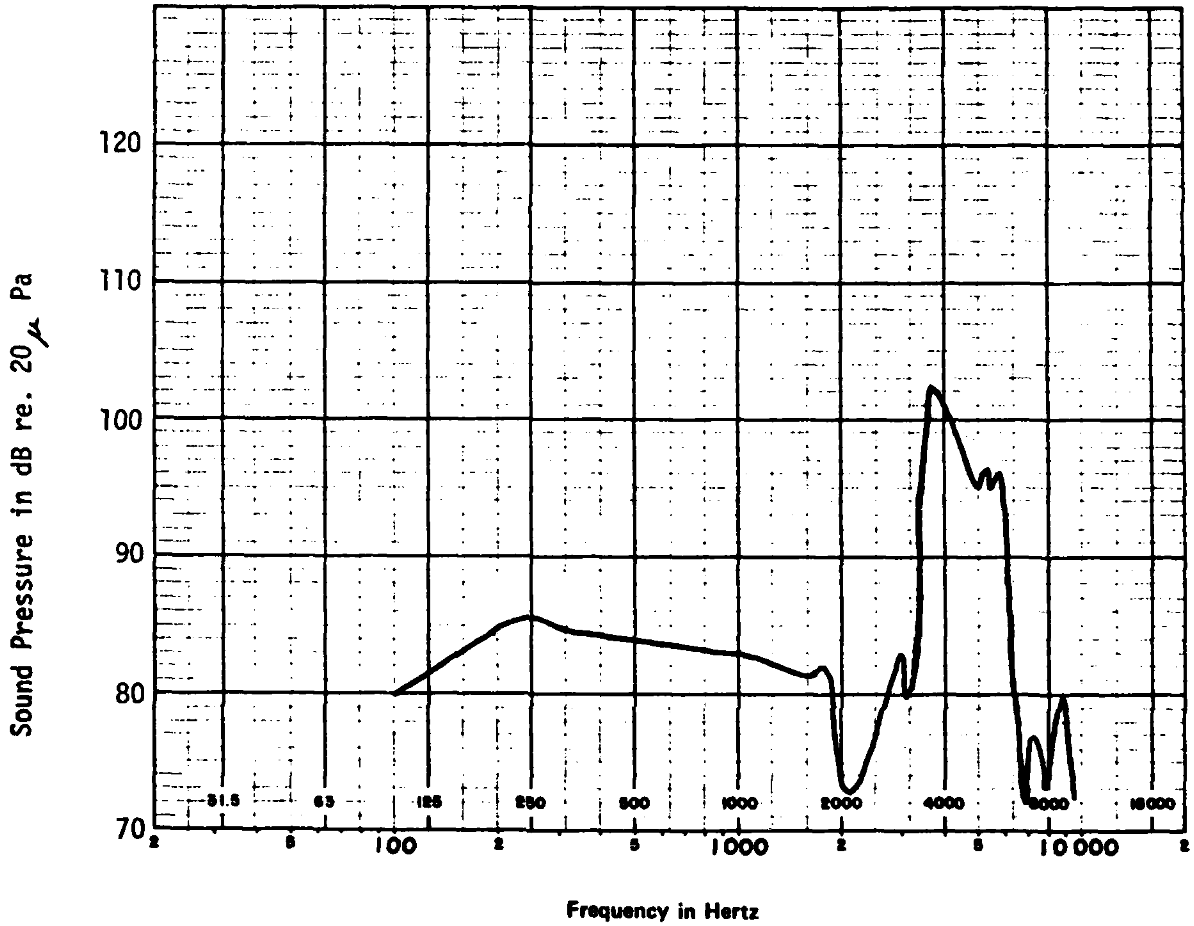
TABLE 2 OF MIL-STD-1474A REPRODUCED IN PART

STEADY-STATE NOISE LIMITS FOR CATEGORIES
OF PERSONNEL OCCUPIED AREAS

Octave Band Center Frequency	Category D
63 Hz	106 dB SPL (re 0.0002 dynes/cm^2)
125	96
250	89
500	83
1000	80
2000	79
4000	79
8000	81
	85 dB (A)

85 dB(A) agrees with TB-MED-251 7 March '72 for 8 hours exposure.

TABLE I



MODEL 993 EARPHONE IN DH-132 EARCUP,
1 mW APPLIED

Figure 2

This system is in present use. The effect of the earplugs on this already poor response has not been measured to the knowledge of the writer, but they most certainly don't help intelligibility.

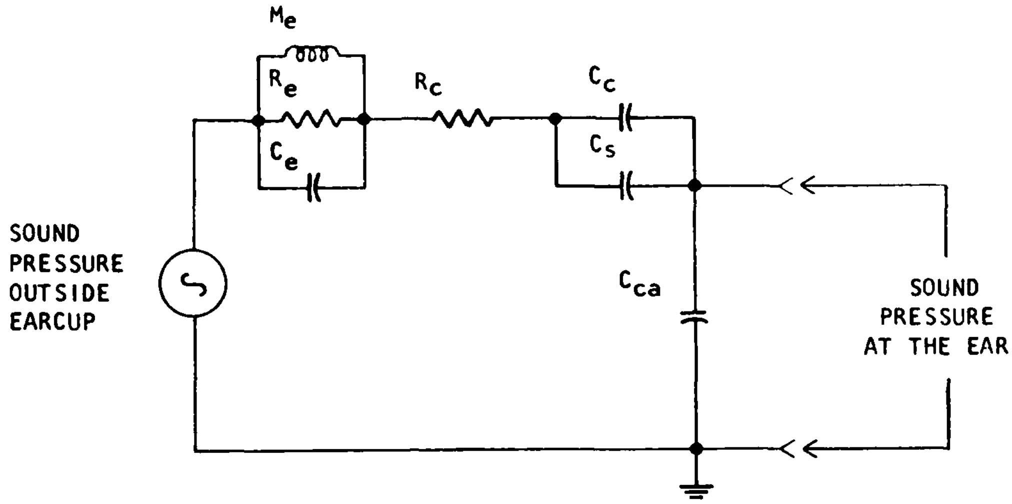
THE IDEAL SOLUTION

If an earcup could be developed that would provide sufficient attenuation to meet the requirements of MIL-STD-1474A while being worn by a passenger in a vehicle such as the IFV without earplugs, then half of the problem is solved. If, further, an earphone element could be developed to provide essentially flat response in the aforementioned earcup, the other half of the problem is solved. This goal generated the effort described herein.

SYSTEM DESIGN

THE EARCUP

In order to understand the noise-attenuation of an earcup, we used a simulation of the system to find possible areas for improvements. An electrical equivalent circuit of an earcup was used along with a digital computer to evaluate the effects of changing various parameters of the earcup on its attenuation qualities. The electrical model shown in Figure 3 is an attempt to simulate an actual earcup. Provision is made to include values for stiffness, mass, compliance of the earcushions, compliance of the skin and other measurable parameters.



M_e = Mass of total earcup system

R_e = Damping of earcup plastic material

C_e = Compliance of earcup

R_c = Damping of earcushion (Ignores damping of skin as earcushion value is much larger)

C_c = Compliance of earcushion

C_s = Compliance of skin

C_{ca} = Compliance of earcup cavity

ELECTRICAL CIRCUIT SIMULATION OF SINGLE EARCUP SYSTEM

Figure 3

In addition, the designers kept the following conditions as guides to keep the new product within the realm of reason.

1. The weight of the earcup should not be more than that of the DH-132 cup so as to not increase wearer fatigue.
2. A means must be provided to retain the earphone element.
3. Insulating material must be used for the earcups to preclude any electrical shock hazard.
4. The boom microphone and electrical connection, connector and cords must be those of the DH-132.

It was determined in a previous effort[1] that "slow foam" material in the ear-cushions is a big help in reducing noise feedthrough by reducing earcup motion. This earcup motion is the primary path by which low-frequency noise reaches the ear. This slow foam, sold under the trade name of Temper Foam, is impregnated with an elastomer that adds considerable resistance to flexure of the material. The foam can be purchased in several static stiffnesses, but the medium stiffness seems to have the best qualities. The ideal quality in the foam is the ability to conform to the contour of the wearer's head but still be stiff enough to prevent cup motion.

The foam has one quality that must be contended with. The static stiffness is dependent upon temperature. We have found, however, that the foam quickly adjusts to the wearer's skin temperature and a foam that has the desired qualities at skin temperature was chosen.

```
10 REM  PROGRAM WHICH CALCULATES TRANSFER FUNCTION OF SINGLE CAVITY EARCUP
20 OPEN "O",#1,"LP:"
30 DIM TO(30),T1(30),N(30)
40 TO(1)=20
50 FOR X=2 TO 28
60 TO(X)= TO(X-1)*1.259:NEXT    'APPROX. THIRD OCTAVE FREQUENCIES
70 M=190                          'MASS OF TOTAL SYSTEM
80 C1=7E-08                       'COMPLIANCE OF CUSHION
90 C2=2.5E-08                     'COMPLIANCE OF CAVITY
100 C3=1E-10                       'STIFFNESS OF EARCUP WALLS
110 R=500                          'RESISTANCE OF CUSHION
120 R1=200000!                     'RESISTANCE OF EARCUP WALLS
130 PRINT #1,TAB(15);"SIMULATION OF DH-132 EARCUP"
140 PRINT #1,"THE COMPONENT VALUES ARE:"
150 PRINT #1, TAB(10);"CUSHION COMPLIANCE=";C1
160 PRINT #1, TAB(10);"CAVITY COMPLIANCE=";C2
170 PRINT #1, TAB(10);"MASS OF SYSTEM=";M
180 PRINT #1, TAB(10);"STIFFNESS OF EARCUP=";C3
190 PRINT #1, TAB(10);"RESISTANCE OF CUSHION=";R
200 PRINT #1, TAB(10);"RESISTANCE OF EARCUP WALLS=";R1
210 PRINT #1,:PRINT #1,"-------------------------------------------------"
220 PRINT #1,
230 FOR A=1 TO 28 STEP 2
240 FOR B=A TO A+1
250 T1(B)=TO(B)*6.28318: T2=T1(B)*T1(B): T3=T2*T1(B)
260 G1=C2/C1+1
270 G2=C2*C3*T2-C2/M
280 G3=(1/(R1*R1))+((C3*T1(B)-1/(M*T1(B)))*(C3*T1(B)-1/(M*T1(B))))
290 G4=R*C2*T1(B)
300 G5=C2/R1*T1(B)
310 G6=(G1+G2/G3)^2
320 G7=(G4+G5/G3)^2
330 N=1/SQR(G6+G7)
340 N(B)=20*(LOG(N)/LOG(10))        'VALUES SAVED IN ARRAY FOR PLOT ROUTINE
350 NEXT B
360 PRINT #1, TAB(5);"FREQ=";TO(A);"Hz";TAB(35);"ATN=";N(A)
370 PRINT #1, TAB(5);"FREQ=";TO(A+1);"Hz";TAB(35);"ATN=";N(A+1)
380 NEXT A
390 PRINT #1,:PRINT #1,"-------------------------------------------------'
400 END
```

Figure 3a

SIMULATION OF DH-132 EARCUP

THE COMPONENT VALUES ARE:

CUSHION COMPLIANCE= 7E-08
CAVITY COMPLIANCE= 2.5E-08
MASS OF SYSTEM= 190
STIFFNESS OF EARCUP= 1E-10
RESISTANCE OF CUSHION= 500
RESISTANCE OF EARCUP WALLS= 200000

FREQ= 20 Hz	ATN=-2.16595
FREQ= 25.18 Hz	ATN=-1.87525
FREQ= 31.7016 Hz	ATN=-1.40558
FREQ= 39.9123 Hz	ATN=-.64014
FREQ= 50.2497 Hz	ATN= .613304
FREQ= 63.2643 Hz	ATN= 2.57276
FREQ= 79.6498 Hz	ATN= 4.32519
FREQ= 100.279 Hz	ATN= 1.42255
FREQ= 126.251 Hz	ATN=-3.91892
FREQ= 158.95 Hz	ATN=-8.56129
FREQ= 200.119 Hz	ATN=-12.413
FREQ= 251.949 Hz	ATN=-15.6905
FREQ= 317.204 Hz	ATN=-18.5592
FREQ= 399.36 Hz	ATN=-21.1389
FREQ= 502.795 Hz	ATN=-23.5173
FREQ= 633.018 Hz	ATN=-25.7574
FREQ= 796.97 Hz	ATN=-27.9023
FREQ= 1003.39 Hz	ATN=-29.9796
FREQ= 1263.26 Hz	ATN=-32.0043
FREQ= 1590.45 Hz	ATN=-33.9818
FREQ= 2002.37 Hz	ATN=-35.908
FREQ= 2520.99 Hz	ATN=-37.7704
FREQ= 3173.92 Hz	ATN=-39.5468
FREQ= 3995.97 Hz	ATN=-41.2062
FREQ= 5030.93 Hz	ATN=-42.7111
FREQ= 6333.94 Hz	ATN=-44.0238
FREQ= 7974.43 Hz	ATN=-45.1165
FREQ= 10039.8 Hz	ATN=-45.9802

Figure 3b

TWO EARCUPS

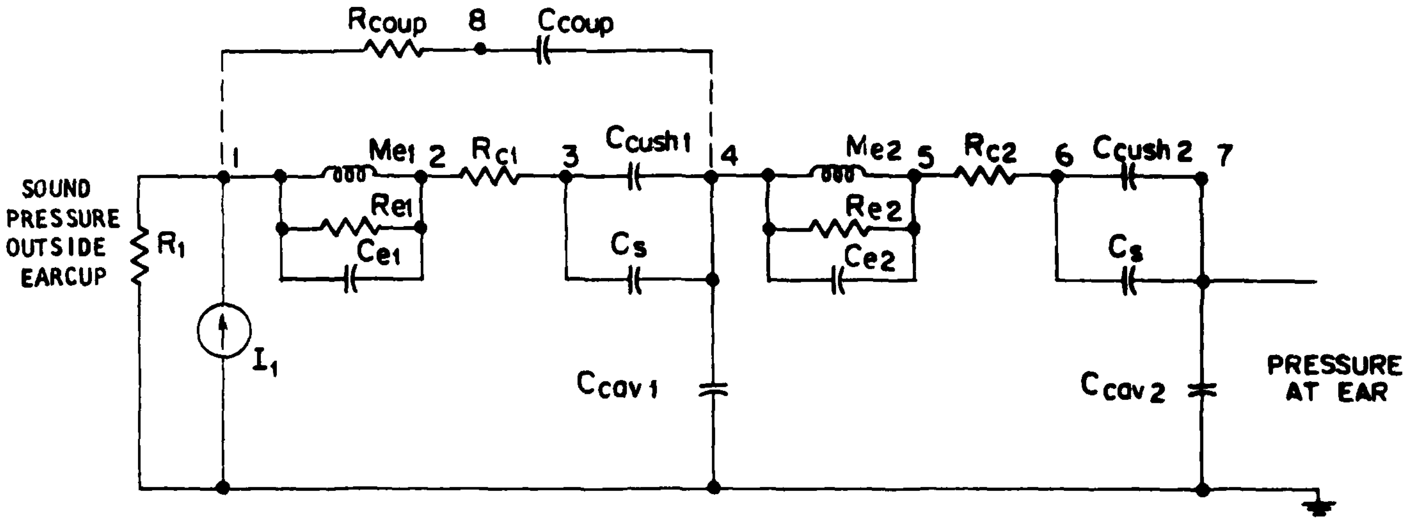
The above methods have produced earcups that have shown considerable improvement in intelligibility and noise attenuation.[1,2] However, neither of these previous earcup-earphone systems have bridged the gap between the MIL-STD-1474A dictates and the noise generated in the IFV. In order to improve on the performance of these two earlier efforts, a two-cup system was envisioned. Figure 4 shows an electrical simulation of a two-cup earcup.

The two-cup simulation was programmed into a digital computer using the circuit analysis program reproduced in Figure 4. Values were chosen for the various parameters by either measuring a prototype part directly or by estimating the value by comparing it to a known. The values chosen for the parameter are tabulated in Table 2.

Figures 4-a,b,c show a print-out of the theoretical attenuation of the system. Note that, at low frequencies, the predicted attenuation of 20 to 30 dB is in the range desired.

The decision to continue with the two-cup approach was followed partly because of the above results. The main reason for following the approach was the belief that two cushions would seal better to the wearer's skin and would attenuate closer to the predicted than a one-cushion approach.

The design of the two-cup system is illustrated in Figures 5 and 6. These photos were taken of a functioning unit. The outer cup contains the switch, cable strain relief, and all the connections. A terminal strip is provided



M_e =Mass of earcup

R_e =Damping of earcup plastic material

C_e =Compliance of earcup

R_c =Damping of earcushion

C_c =Compliance of earcushion

C_s = Compliance of skin

C_{ca}=Compliance of earcup cavity

(Subscript 1 refers to larger cup, 2 refers to smaller cup)

ELECTRICAL CIRCUIT SIMULATION OF DOUBLE EARCUP SYSTEM

Figure 4

```
10 REM  PROGRAM WHICH CALCULATES TRANSFER FUNCTION OF DUAL CAVITY EARCUP
20 OPEN "O",#1,"LP:"
30 DIM TO(30),T1(30),N(30)
40 TO(1)=20
50 FOR X=2 TO 28
60 TO(X)= TO(X-1)*1.259:NEXT    'APPROX. THIRD OCTAVE FREQUENCIES
70 M1=140                       'MASS OF OUTER EARCUP
80 M2=80                        'MASS OF INNER EARCUP
90 C1=2.8E-09                   'COMPLIANCE OF OUTER CUSHION
100 C2=1E-08                    'COMPLIANCE OF OUTER CAVITY
110 C3=2.3E-08                  'COMPLIANCE OF INNER CAVITY
120 C4=5E-08                    'COMPLIANCE OF INNER CUSHION
130 R1=200000!                  'RESISTANCE OF EARCUP WALLS
140 PRINT #1,TAB(15);"SIMULATION OF DUAL CAVITY EARCUP"
150 PRINT #1,"THE COMPONENT VALUES ARE:"
160 PRINT #1, TAB(10);"OUTER CUSHION COMPLIANCE=";C1
170 PRINT #1, TAB(10);"INNER CUSHION COMPLIANCE=";C4
180 PRINT #1, TAB(10);"OUTER CAVITY COMPLIANCE=";C2
190 PRINT #1, TAB(10);"INNER CAVITY COMPLIANCE=";C3
200 PRINT #1, TAB(10);"MASS OF OUTER EARCUP=";M1
210 PRINT #1, TAB(10);"MASS OF INNER EARCUP=";M2
220 PRINT #1, TAB(10);"RESISTANCE OF EARCUP WALLS=";R1
230 PRINT #1,:PRINT #1,"------------------------------------------------------------"
240 PRINT #1,
250 FOR A=1 TO 28 STEP 2
260 FOR B=A TO A+1
270 T1(B)=TO(B)*6.28318: T2=T1(B)*T1(B): T4=T2*T2
280 G1=M1*M2*T4
290 G2=(M2/C2+M1/C2+M1/C3+M1/C4+M2/C1+R1*R1)*T2
300 G3=1/C1*C3+1/C1*C2+1/C2*C3+1/C2*C4+1/C1*C4
310 G4=(2*R1/C2+R1/C1+R1/C3+R1/C4)*T1(B)
320 G5=(R1*M2+R1*M1)*T1(B)*T2
330 G6=(G1-G2+G3)*1E-10
340 G7=(G4-G5)*1E-10
350 D=(G6*G6)+(G7*G7)
360 N=1/(C2*C3*SQR(D)*1E+10)
370 N(B)=20*(LOG(N)/LOG(10))        'VALUES SAVED IN ARRAY FOR PLOT ROUTINE
380 NEXT B
390 PRINT #1, TAB(5);"FREQ=";TO(A);"Hz";TAB(35);"ATN=";N(A)
400 PRINT #1, TAB(5);"FREQ=";TO(A+1);"Hz";TAB(35);"ATN=";N(A+1)
410 NEXT A
420 PRINT #1,:PRINT #1,"------------------------------------------------------------"
430 END
```

Figure 4a

SIMULATION OF DUAL CAVITY EARCUP

THE COMPONENT VALUES ARE:

OUTER CUSHION COMPLIANCE= 2.8E-09
INNER CUSHION COMPLIANCE= 5E-08
OUTER CAVITY COMPLIANCE= 1E-08
INNER CAVITY COMPLIANCE= 2.3E-08
MASS OF OUTER EARCUP= 140
MASS OF INNER EARCUP= 80
RESISTANCE OF EARCUP WALLS= 200000

FREQ= 20 Hz	ATN=-11.0913
FREQ= 25.18 Hz	ATN=-13.0891
FREQ= 31.7016 Hz	ATN=-15.0852
FREQ= 39.9123 Hz	ATN=-17.0788
FREQ= 50.2497 Hz	ATN=-19.0681
FREQ= 63.2643 Hz	ATN=-21.0504
FREQ= 79.6498 Hz	ATN=-23.0209
FREQ= 100.279 Hz	ATN=-24.9715
FREQ= 126.251 Hz	ATN=-26.8883
FREQ= 158.95 Hz	ATN=-28.7501
FREQ= 200.119 Hz	ATN=-30.541
FREQ= 251.949 Hz	ATN=-32.352
FREQ= 317.204 Hz	ATN=-34.8591
FREQ= 399.36 Hz	ATN=-39.7976
FREQ= 502.795 Hz	ATN=-47.2581
FREQ= 633.018 Hz	ATN=-55.4864
FREQ= 796.97 Hz	ATN=-63.7404
FREQ= 1003.39 Hz	ATN=-71.9137
FREQ= 1263.26 Hz	ATN=-80.0222
FREQ= 1590.45 Hz	ATN=-88.0893
FREQ= 2002.37 Hz	ATN=-96.1313
FREQ= 2520.99 Hz	ATN=-104.158
FREQ= 3173.92 Hz	ATN=-112.175
FREQ= 3995.97 Hz	ATN=-120.187
FREQ= 5030.93 Hz	ATN=-128.195
FREQ= 6333.94 Hz	ATN=-136.201
FREQ= 7974.43 Hz	ATN=-144.205
FREQ= 10039.8 Hz	ATN=-152.209

Figure 4b

ENGINEERING RESEARCH

TITLE: THEORETICAL ATTENUATION BELOW 1 KHZ

DATE

SPECIAL NOTES

Plotted from data in Figure 4b

ANALYZER BANDWIDTH

LOG CONVERTER SPEED OR TIME CONSTANT

SWEEP SPEED

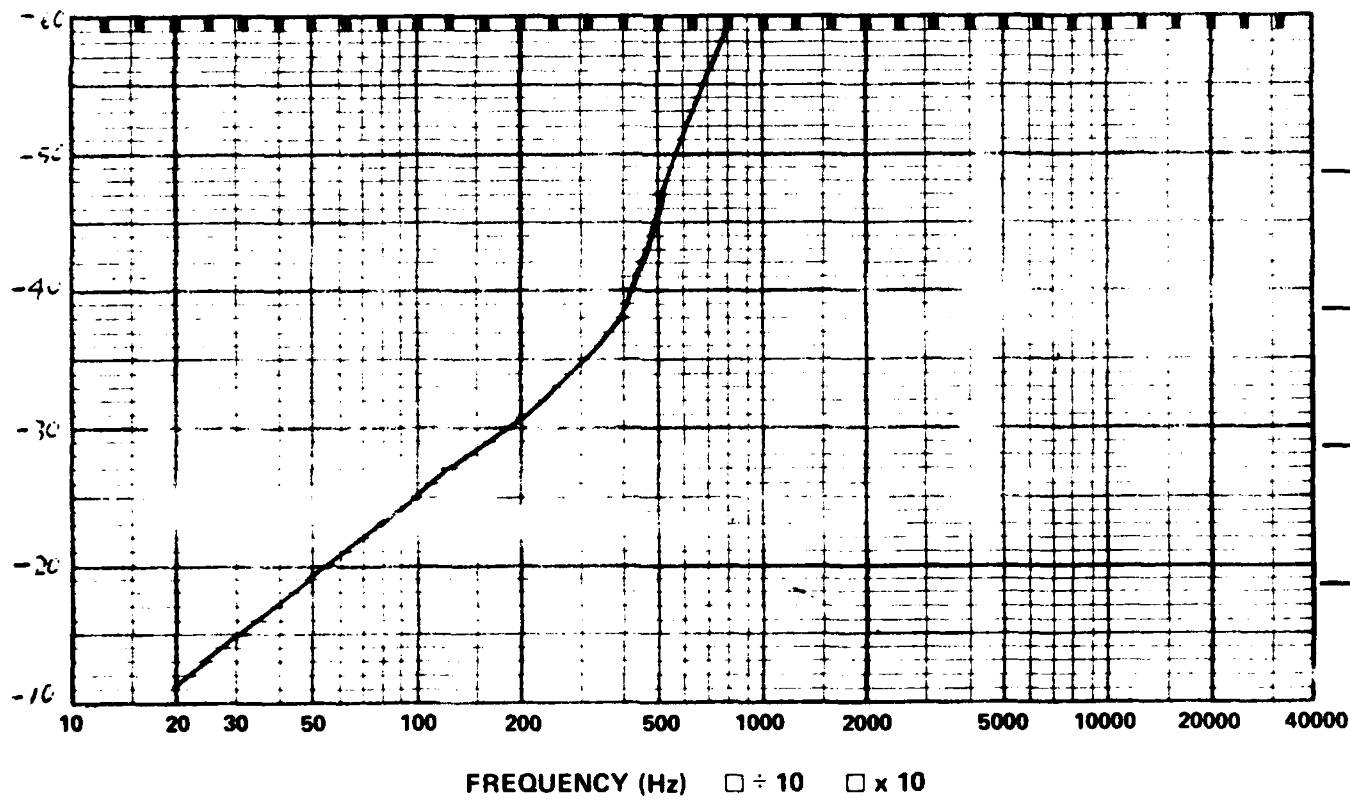


Figure 4c

VALUES PICKED FOR DOUBLE CUP SIMULATION

M_1	=	140 gms	Mass of outer earcup
M_2	=	80 gms	Mass of inner earcup
C_1	=	2.8×10^{-9} cm/dyne	Compliance of outer cushion
C_2	=	1.0×10^{-8} cm/dyne*	Compliance of outer cavity
C_3	=	2.3×10^{-8} cm/dyne*	Compliance of inner cavity
C_4	=	5.0×10^{-8} cm/dyne	Compliance of inner cushion
R_1	=	200,000 ohms (mech)	Resistance of earcup walls

C_2 and C_3 are actually acoustic cavities that are converted to mechanical compliances so that the simulation is that of an all mechanical system.

TABLE 2

COMPARISON OF ATTENUATION DATA ON STOCK DH-132 AVC HELMET EARCUP TO EFFORT OF '78-'79 AND PRESENT EFFORT

Frequency	Stock DH-132 Cup on ANSI Fixture	'78-'79[2] Effort on ANSI Fixture	Present Effort on ANSI Fixture	Present Effort on Human Head
125	6	14	22	21.3
250	21	22	25	27.3
500	28	30	35	40.0
1000	31	35	45	47.3
2000	40	39	55	43.7
4000	35	44	51	55.0
8000	33	46	58	52.0

TABLE 2a

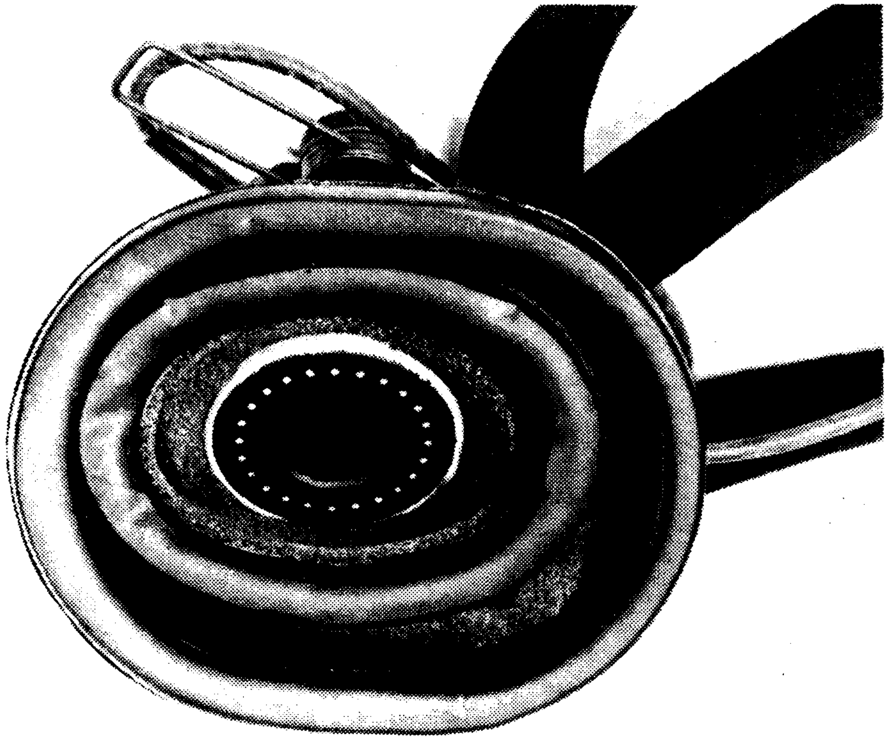


Figure 5

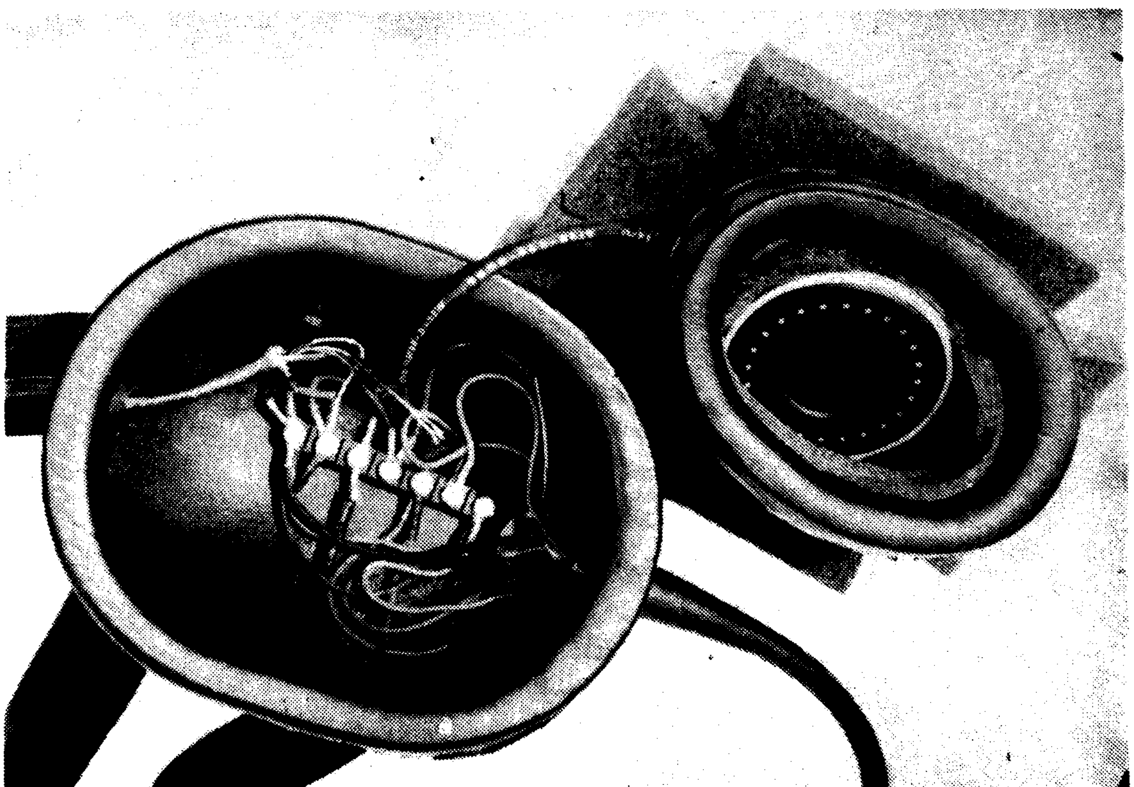


Figure 6

for ease of replacing individual components. The foam piece attached to the smaller cup retains it within the larger cup and also provides a spring force to hold it against the wearer's head.

The shape of both cups is as nearly spherical as practical since a spherical surface is the most rigid and least likely to "drumhead", or pass sound through its walls. The inner cup contains the receiver element and places it so that it is close to the wearer's ear but not touching. This cup is a complete earcup with its own earcushion and foam liner.

The outer cup is very similar to a DH-132 cup designed to meet the requirements of MK-1039. Its shape was chosen to clear the inner cup and still have the lowest profile possible in order to clear obstacles and to fit under a future helmet design.

The retention method is only intended to hold the earcups on the wearer's head for evaluation purposes. Velcro tape was used because it is easily adjusted for various head sizes. We envision a retention system within a new helmet design that would approximate this method in that it would provide a three-point support approximately at the chin, nape and forehead areas. The brackets are allowed to swivel to accommodate various head profiles. They probably would not be required in the helmet harness as the angle of pull could be different in each helmet size. Figure 7 shows a headset installed on a dummy head.

Actual attenuation data for the earcup on the writer's head is tabulated in Table 3.

Figure 7

REAL EAR THRESHOLD ATTENUATION ACHIEVED

R. Jackson	1st Test	2nd Test	3rd Test	Average	IFV Noise Worst Case	Difference	Weighted
125 Hz	24 dB	20 dB	26 dB	23.3	128	104.7	88.3
250	32	28	22	27.3	126	92.7	84.1
500	38	36	46	40.0	116	76.0	72.7
1000	46	46	50	47.3	109	61.7	61.7
2000	42	46	43	43.7	108	64.3	65.7
4000	60	50	55	55.0	103	48.0	49.8
8000	52	48	56	52.0	97	45.0	46.9

Combined "A" Weighted ---- 89.6 dBA

Additional data on nine other heads and data taken on the ANSI fixture appear in the Design Test Report.

TABLE 3

THE EARPHONE ELEMENT

Producing an intelligible signal within the cup is as important to good communications as blocking out the ambient noise. With this idea in mind, we set out to develop an earphone element that would produce the flattest response at an acceptable level in the earcup as perceived by the human ear.

The new element is similar in design to one dubbed the "Linear Earphone" in an earlier effort.[1] It is designed to work into the combined cavity of the human ear and the earcup and must be specified in the earcup developed during the effort.

Response curves of the earphone element on a human head and on a flat plate are shown in Figure 8. The real head response was obtained by placing a tiny (1/4" x 1/8" x 1/16") electret microphone on an earplug and inserting it in a person's ear. The earcup containing the earphone element to be measured was then placed over the ear as it would be worn in actual use. The person wearing the setup must then remain still while a signal is swept through the element and received by the tiny microphone.

The flat plate response was obtained using the attenuation test fixture described in ANSI S3.19-1974. For general information, a drawing is presented in Figure 9. A 1-inch B & K condenser microphone contained in the fixture is used to measure the response.

MODEL Unit #48

SPECIAL NOTES ——— Flat Plate Response

----- Real Ear Response

Z ______ OHMS DATE ______

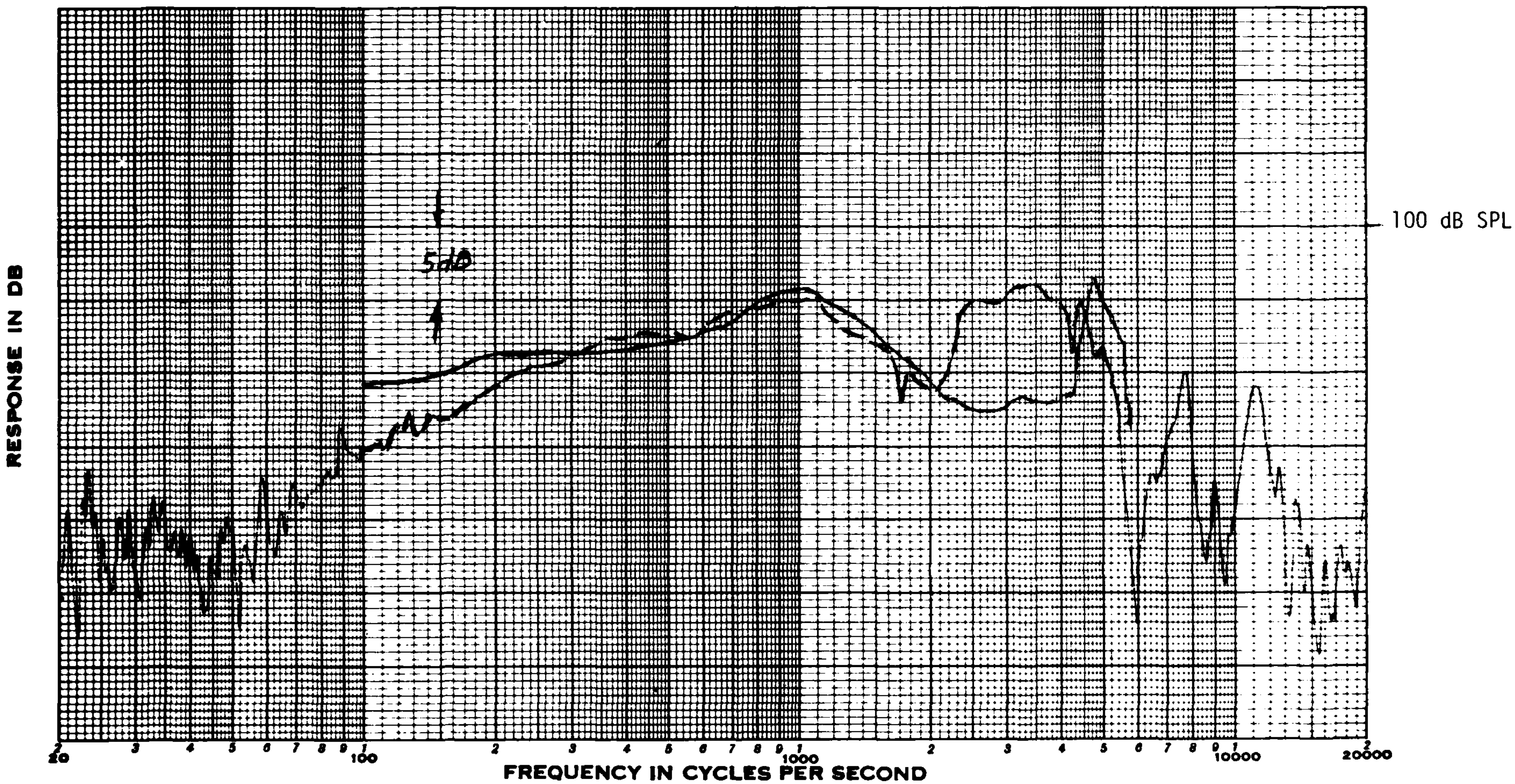
SOUND PRESSURE ______ DB re .0002 dynes/cm²

REFERENCE: 0 DB =

MICROPHONE PLACEMENT ______ inches

SENSITIVITY ______ db re 1 volt/dyne

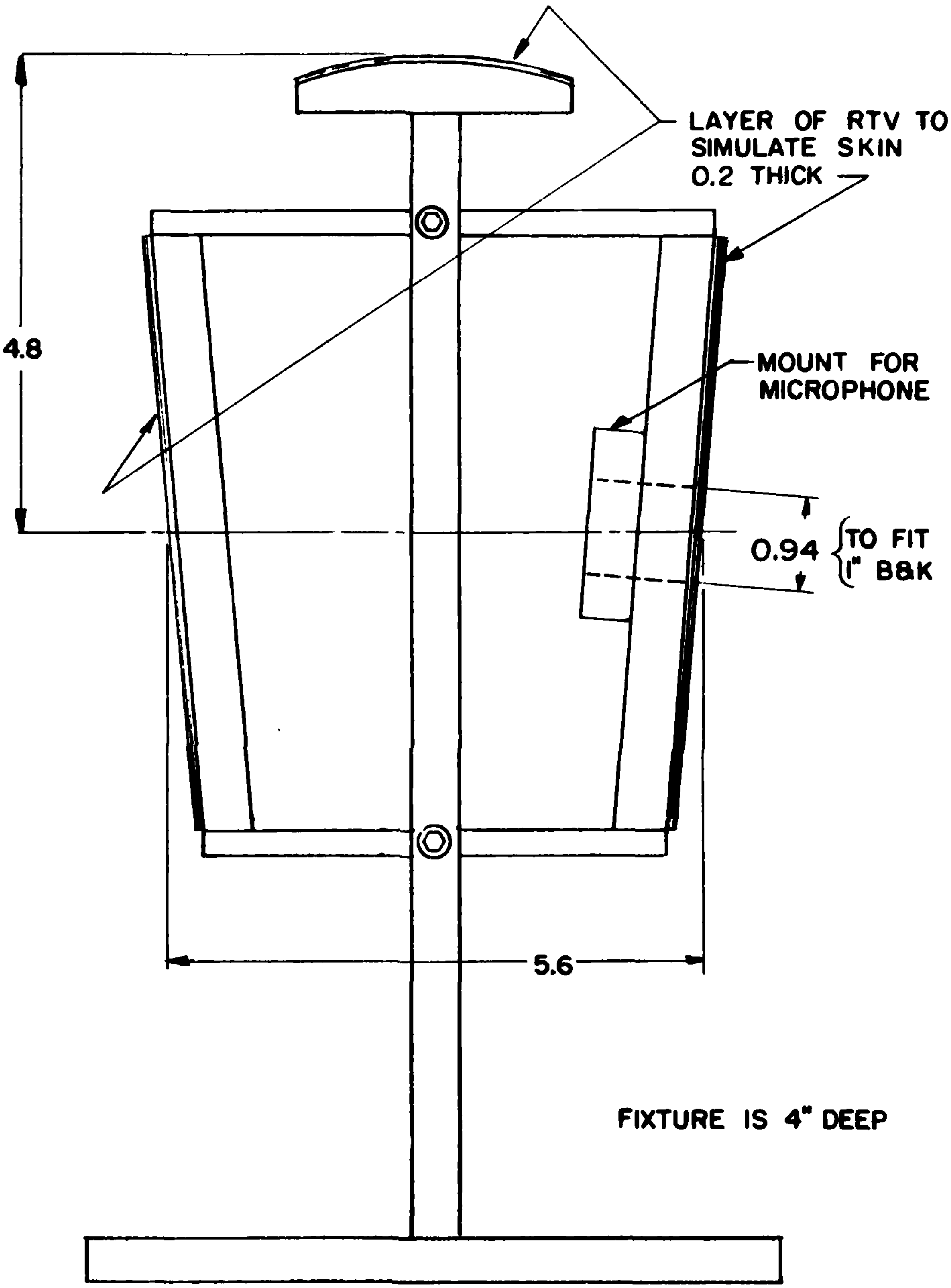
AT ______ CPS ______ db re 1 milliwatt/10 dynes



Electro-Voice

APPROVED ______

Figure 8



A RENDITION OF FIXTURE DESCRIBED IN ANSI S3.19-1974

Figure 9

A STUDY OF THE EFFECT OF CONTAMINANTS ON URETHANE FILM

A study was made to determine the effect of various contaminants on the earcushion cover material. An earlier study determined that the urethane film being used on this and two previous developments had ideal temperature qualities. It does not stiffen appreciably at -40° and maintains its shape at 165° F.

To conduct the contaminant study, a fixture was fabricated per method 5200 of Federal Test Method Standard No. 191. A drawing is provided in Figure 10. In addition, a quantity of test strips were cut one inch wide by ten inches long. The strips were individually attached to the fixture to determine the "droop" of clean urethane film of the thickness being used. Next, several of the strips were coated with each of the contaminants listed below. After the periods of time listed, they were again attached and the new "droop" measured. A decrease in droop would indicate an increase in stiffness and an increase in droop would indicate a decrease in stiffness.

CONTAMINATE	CHANGE IN DROOP (+ or –)	RESULT
Vitalis Hair Tonic	+ 7/32	Soften
Water	+ 6/32	Soften
Hand Cream*	+ 11/32	Soften
Motor Oil	+ 8/32	Soften

* Avon Vita-Moist Hand Cream contains water, glycerin, glycol, stearate, beeswax, lanolin oil, sesame oil, glyceryl oleate, glyceryl stearate, isopropyl myristate, myristyl myristate, stearett-2, triethonolamine, sodium glyceryl oleate phosphate, carbomer-940 fragrance, formaldehyde, FD & CY yellow #5.

DIRECTIONAL STIFFNESS HANGING LOOP APPARATUS

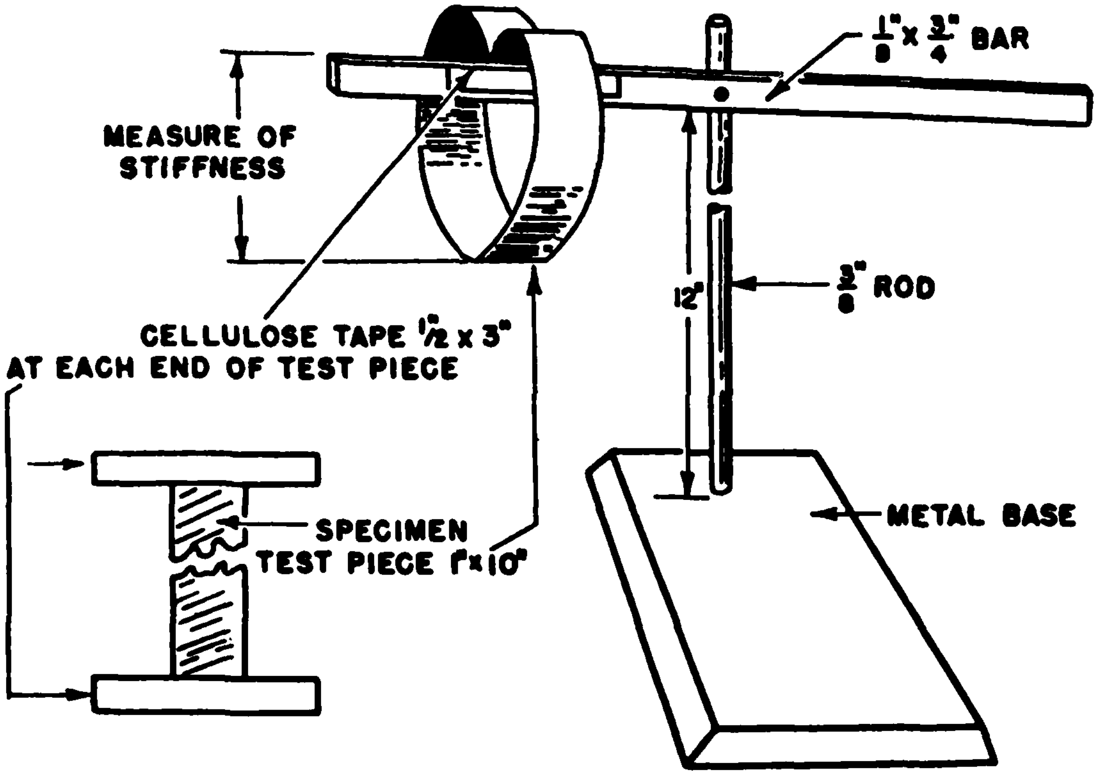


Figure 10

THE MICROPHONE CONNECTOR WATERPROOFING BOOT

Another development included in this effort was that of a method to waterproof the junction of U-172/U to U-173/U connectors or the junction of JJ-055 to PJ-292 connectors. What resulted was a device that will do the above and also handle the U-172/PJ-292 and the U-173/JJ-055 combinations. Figure 11 is a drawing of the boot.

For best results we recommend the following:

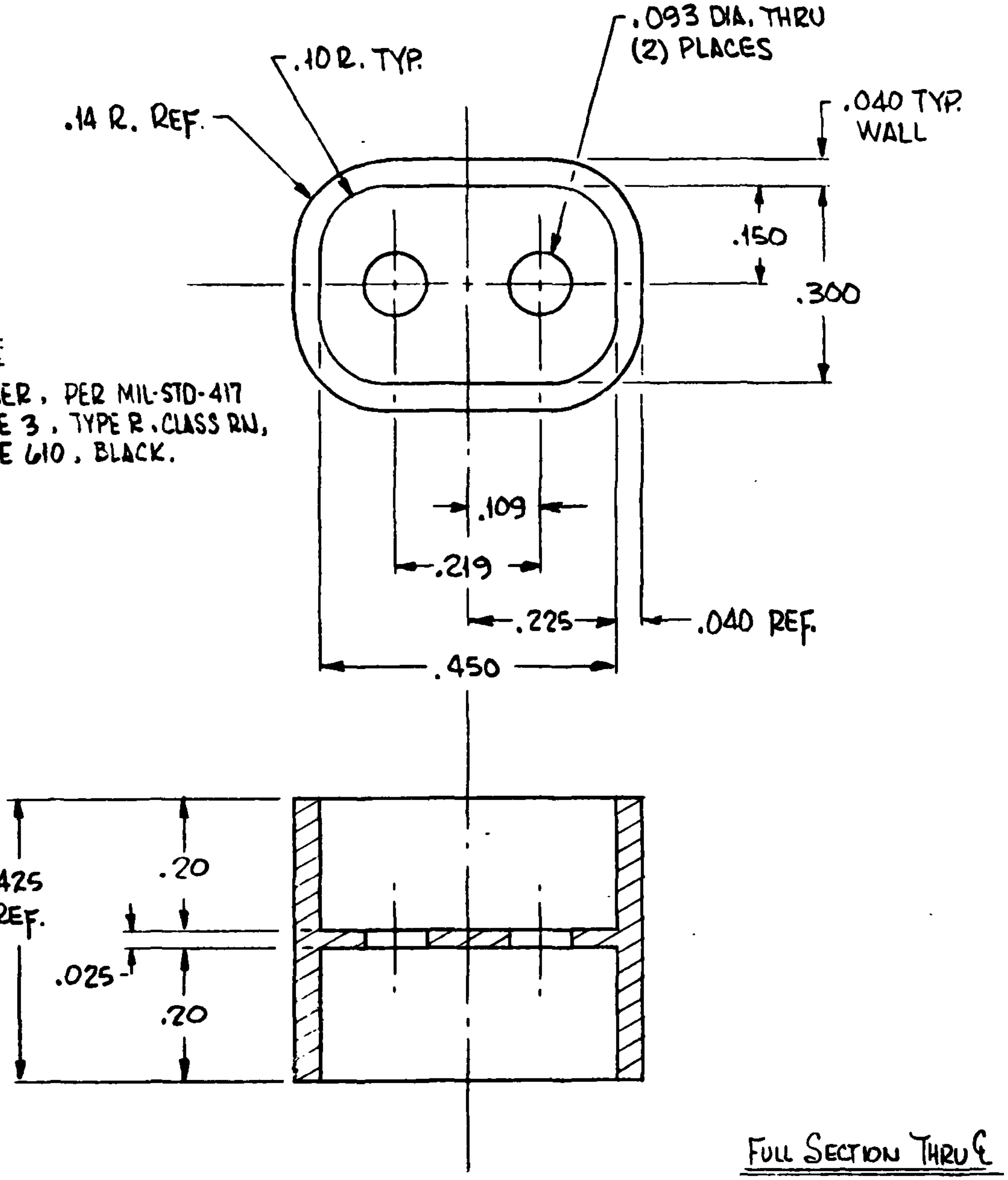
1. After assembling the connector to the cable, fill it with potting compound or epoxy to seal the connector internally.
2. Cement the boot to one of the connectors, preferrably the male, using a rubber compatible cement.
3. When fabricating the boot, pay close attention to the thickness of the inner web. Making this web too thick will prevent the detents in the connectors from working.

CORROSION INVESTIGATION

The metal parts used in this effort were subjected to a 20% NaCl salt spray for 48 hours to see if special anticorrosion techniques would be needed. The results showed no more discoloration than the standard 5% salt spray and no corrosion.

CONCLUSIONS AND RECOMMENDATIONS

The earcup-earphone headset developed during this effort is a definite improvement over equipment available to the infantryman today. This system is a further improvement over the two previous efforts by this group



MAT'L:

RUBBER, PER MIL-STD-417
TABLE 3, TYPE R, CLASS RN,
GRADE 610, BLACK.

FULL SECTION THRU ℄

REV.	DESCRIPTION	APPROVAL & DATE

UNLESS OTHERWISE SPECIFIED

ALL DIMENSIONS IN INCHES EXCEPT METRIC IN (PAREN.)

INCHES X 25.4 = MM — MM X .0394 = INCHES

TOLERANCES

INCHES		METRIC		ANGLES	
.X	± .030	X.	± .8MM	MACHINED / CAST / MOLDED	± 1/2°
.XX	± .010	.X	± .3MM		
.XXX	± .005	.XX	± .1MM	FORMED	± 2°

CONCENTRICITY — T.I.R. | DRAFT ANGLES —

MATERIAL — NOTED — | FROM —

REMOVE ALL BURRS AND SHARP EDGES
THREADS TO BE UNIFIED SERIES
CLASS 2 AFTER PLATING

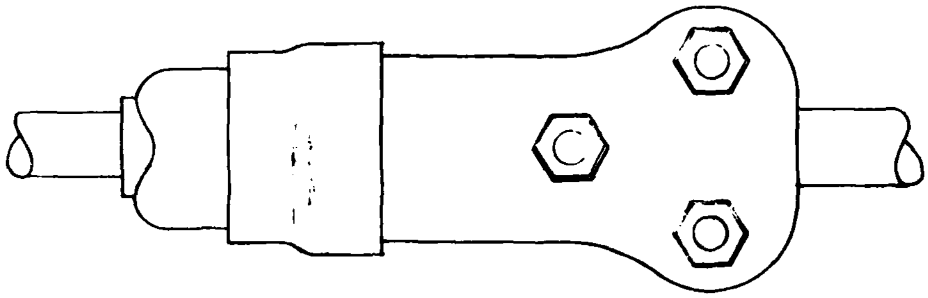
ELECTRO-VOICE, INC.
a GULTON subsidiary
BUCHANAN, MICHIGAN 49107

TITLE WATERPROOFING BOOT, U173

SCALE 4:1		MODEL FIRST USED ON SALES / ENGINEERING
DRN JWB	DATE 12-15-80	PRODUCTION NO. / REV.
CKD [signature]	DATE 12-20-80	
ENGR [signature]	DATE 12-20-80	

EXPERIMENTAL NO. E 36-992-8

Figure 11



Waterproofing Boot on U-173/U and JJ-055 Connectors

Figure 12

referred to in this report. Table 2 on page 15 compares the attenuation results of a previous effort to the present one by this group.

Examination of the attenuation results of the author, shown in Table 3, shows that the headset very nearly meets the worst case noise exposure for eight hours. This worst case exposure was calculated from noise data obtained from USAARL Report No. 77-8 of a prototype combat vehicle operating at 35 MPH on an asphalt track. The headset does not quite provide sufficient attenuation in the 125 and 250 Hz octave bands to meet this worst case. However, comparing the 91 dBA obtained on one head to the 89.6 dBA derived from MIL-STD-1474 Cat. D shows very near compliance. Under normal conditions we would expect the headset to provide attenuation to meet requirements for eight hours of exposure to noise under Category D of MIL-STD-1474A.

Unfortunately, the goal of providing a headset that would preclude the use of earplugs under all operating conditions was not reached. Parameters such as the compliance of human skin, the leakage through human hair and the maximum practicable weight for earcups put restrictions on headsets that just might prevent anyone ever designing a system that will preclude need for earplugs in the IFV, if the worst case data is realistic. The large improvement in the attenuation of the 500 Hz and above octave bands should reduce the increased hazard caused by the communications system. In other headset configurations the volume of the communications system is turned up so high for intelligibility that the acoustic hazard is increased.

The study of the effect of contaminants on the earcushion covers shows urethane to be an ideal material for this application. This group first used the material in 1977 on a cup for the SPH-4 earcup redesign and since then several earcushion fabricators have used it.

The boom microphone connector waterproofing boot is a simple contrivance that works well. Providing that the connectors are potted to insure their waterproofness, the boot will waterproof the junction between connectors. As stated earlier, the thickness of the web must be kept small in order that the connector detents work properly.

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